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Geospatial Assessment of Health Indicators and Public Healthcare Services in Maharashtra, India

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Abstract: Good health is vital for the well-being of individuals and societies. Health indicators such as family planning, child health, and maternal health play a crucial role in determining population health outcomes. This study examines these indicators in Maharashtra, focusing on changes before and after the COVID-19 pandemic. Family planning, child health, and maternal health are critical areas affected by the pandemic's disruptions. The research uses Geographic Information Systems (GIS) to analyze regional disparities in healthcare accessibility and effectiveness, utilizing secondary data from sources like the National Family Health Survey (NFHS), Health Management Information System (HMIS), and Maharashtra State Health Department. Maharashtra, with its diverse socio-economic and geographical conditions, experiences significant health disparities, with urban areas exhibiting better healthcare access compared to rural regions. The study reveals several trends. Family planning in districts like Osmanabad and Solapur showed a decline in the Medical Termination of Pregnancy (MTP) ratio post-COVID, while sterilization rates remain higher in economically weaker districts. Maternal health indicators show a mixed response, with some districts exhibiting delays in early pregnancy registration, while others show improvements in institutional deliveries. Child health indicators highlight improvements in birth weight outcomes in certain districts but also show challenges in immunization coverage and the sex ratio at birth. Healthcare services are unevenly distributed, with rural areas suffering from a shortage of primary healthcare centers and medical professionals. This research emphasizes the need for targeted interventions in rural and underserved areas, focusing on enhancing healthcare infrastructure, maternal and child health services, and family planning programs. It also underscores the importance of using geospatial analysis for efficient resource allocation and policymaking.

Introduction

Good health is fundamental to the well-being and progress of individuals, families, and societies (Lawal and Anyiam, 2019). The World Health Organization (WHO) emphasizes that health is not merely the absence of disease but a state of complete physical, mental, and social well-being (WHO, 2020). The study of health indicators in specific regions is crucial for designing effective public health interventions that cater to local needs (Deshpande et al., 2004; Marmot, 2005). In this context, family planning, child health, and maternal health emerge as key public health concerns that significantly impact population health outcomes (Mondal et al., 2023; Sharma et al., 2024; Gupta et al., 2024). Family planning plays a vital role in reproductive health, allowing individuals and couples to plan and space pregnancies through various contraceptive methods. Studies have shown that access to effective contraception reduces maternal and infant mortality rates and improves overall reproductive health (Cleland et al., 2012). According to the United Nations Population Fund (UNFPA), family planning services help in preventing

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unintended pregnancies, thereby contributing to women's empowerment and socio-economic development (UNFPA, 2019). Child health is another crucial aspect of public health, encompassing immunizations, nutrition, and preventive care. Adequate healthcare during childhood is essential for reducing morbidity and mortality rates among infants and young children. The United Nations Children's Fund (UNICEF) states that child mortality has declined significantly due to advancements in immunization programs and nutrition initiatives (UNICEF, 2021). However, regional disparities in healthcare access persist, necessitating targeted interventions. Maternal health, which includes care during pregnancy, childbirth, and the postpartum period, is a critical determinant of a country's healthcare efficacy. According to the WHO, maternal mortality remains a significant challenge, particularly in developing regions where access to quality maternal healthcare is limited (WHO, 2019). Safe pregnancy and childbirth services are crucial for ensuring the well-being of both mothers and newborns.

The COVID-19 pandemic has had a profound impact on global health systems, disrupting routine healthcare services and exacerbating existing health disparities (Hogan et al., 2020). The pandemic led to a decline in maternal and child health services due to healthcare resource reallocation and mobility restrictions (Roberton et al., 2020). In Maharashtra, one of India's most populous states, these disruptions necessitate a comprehensive analysis of health indicators before and after the pandemic. This study aims to conduct a geospatial comparison of health indicators in Maharashtra, examining variations in family planning, child health, and maternal health before and after COVID-19. Geographic Information Systems (GIS) provide a powerful tool for visualizing health disparities and assessing changes over time (Mooney et al., 2013). By leveraging geospatial techniques, this research will contribute to a better understanding of healthcare accessibility and effectiveness in Maharashtra's diverse regions. Understanding these health dynamics is essential for policymakers, healthcare professionals, and public health organizations to design and implement evidence-based interventions.

Materials and Methods

Maharashtra, one of India's most economically and industrially advanced states, is located in the western part of the country, covering an area of 307,713 square kilometers (Government of Maharashtra, 2021). According to the 2011 Census, Maharashtra has a population of approximately 112 million, making it the second most populous state in India (Registrar General of India, 2011; Mundhe et al., 2020). The state is administratively divided into 36 districts, further grouped into six revenue divisions: Konkan, Pune, Nashik, Aurangabad, Amravati, and Nagpur (Figure 1) (Government of Maharashtra, 2021). Maharashtra exhibits significant urbanization, with over 45% of its population residing in urban areas, making it one of the most urbanized states in India (Bhagat, 2011; Mundhe and Jaybhaye, 2014). Over the decades, Maharashtra's population growth rate has shown a declining trend due to improved socio-economic conditions, health awareness, and family planning initiatives. Figure 2 shows that the decadal growth rate of the state has reduced from 24% in 1961 to 16% in 2011 (Registrar General of India, 2011). This shift indicates an increased emphasis on population control measures and better access to healthcare facilities (Gautham et al., 2014). However, despite these improvements, regional disparities in health indicators persist, necessitating an in-depth spatial analysis (Sritart et al., 2021).

Maharashtra's diverse geographical, social, and economic conditions play a crucial role in shaping health outcomes. The state's varied topography, ranging from the coastal Konkan region to the plateau areas of Vidarbha and Western Maharashtra, influences healthcare accessibility and disease prevalence (Pagar, 2021). Furthermore, economic inequalities between urban and rural areas contribute to disparities in healthcare infrastructure and service delivery (Mishra and Mohanty, 2019). Given these variations, a geospatial approach is essential for assessing health indicators across different regions of Maharashtra. By analyzing spatial patterns in healthcare accessibility, maternal and child health, and family planning services, this study aims to provide a data-driven foundation for targeted public health interventions.

This study employs a secondary data-based approach to assess health indicators across Maharashtra's districts. The primary data sources include the National Family Health Survey (NFHS) reports, which provide extensive health and demographic data at the district level (IIPS & MoHFW, 2021), the Health Management Information System (HMIS), which records real-time health service utilization and outcomes (MoHFW, 2020), and Census of India data, which offers demographic and socio-economic insights (Registrar General of India, 2011). Additionally, reports from the Maharashtra State Health Department are utilized to understand regional health trends and policies (Government of Maharashtra, 2021).

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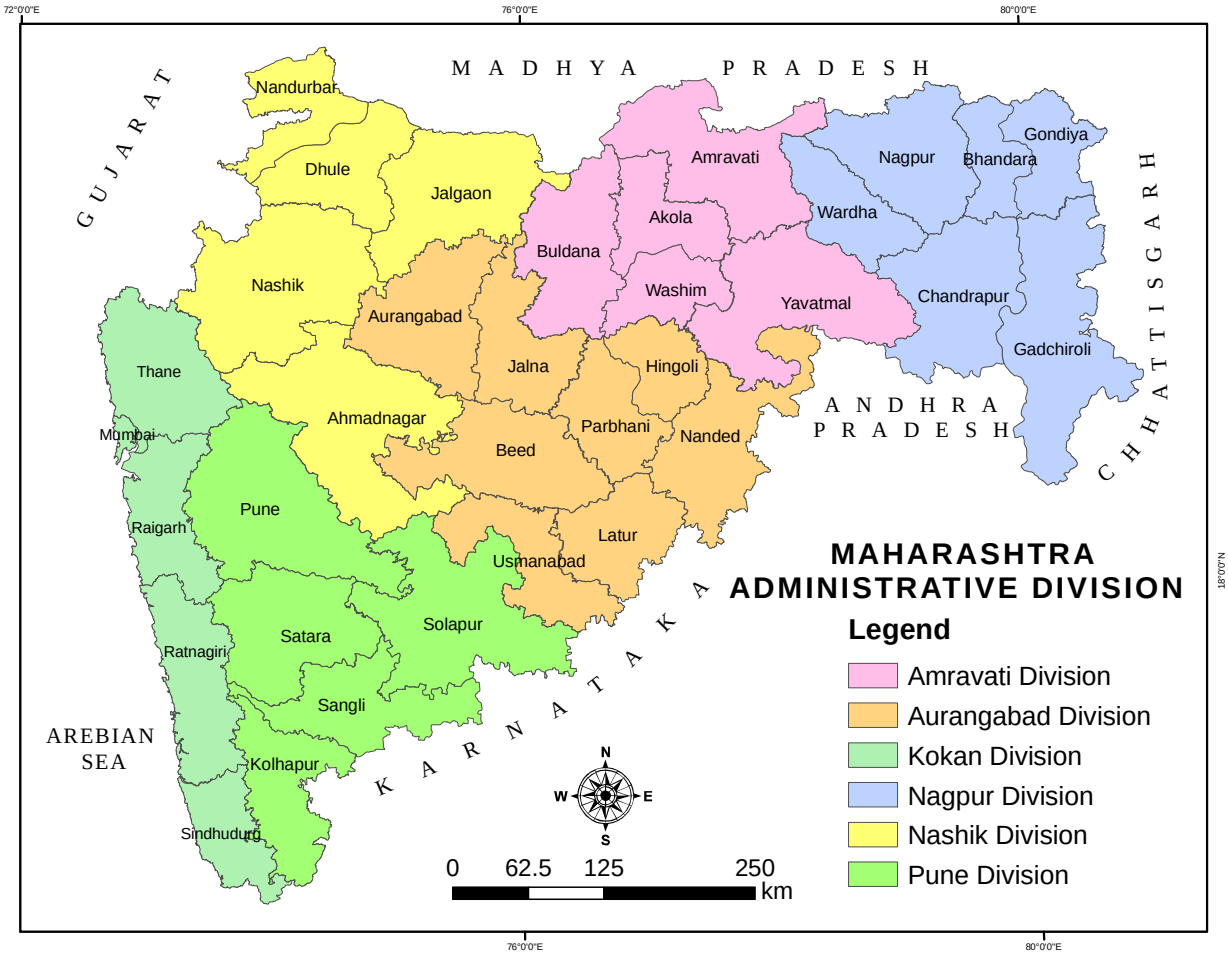

Figure 1. Study area [Note: In this map Palghar District is not showing because map prepared based on Census of India, 2011].

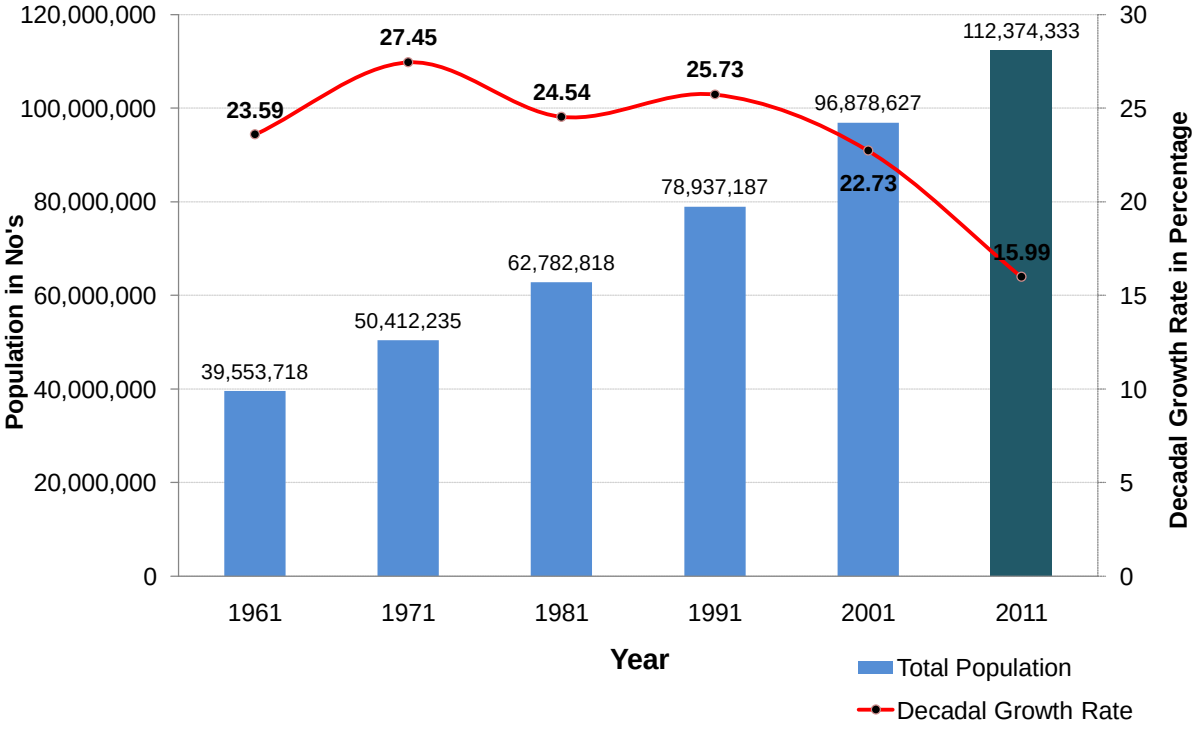

Figure 2. Decadal growth rate of population in Maharashtra state [Source: Generated from Census of India, 2011].

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Districts serve as the unit of analysis in this study, enabling a comparative assessment of health disparities across Maharashtra. The research methodology integrates geospatial techniques with statistical analysis, following these key steps:

1. ***Data collection and attribute procurement:*** Secondary datasets are compiled from official sources, ensuring reliability and consistency (Dutta et al., 2022).
2. ***Geospatial data acquisition:*** Spatial datasets, including district boundaries and healthcare infrastructure locations, are acquired from open GIS repositories and government sources (Longley et al., 2015).
3. ***Data processing and digitization:*** Tabular health data is georeferenced and digitized for spatial analysis (Mishra and Kumari, 2020).
4. ***Statistical and geospatial analysis:*** Classification techniques categorize health indicators pre- and post-COVID. Spatial interpolation and hotspot mapping identify regional disparities (Anselin, 1995; Yasmin and Ghosh, 2019).
5. ***Comparative analysis of pre- and post-COVID periods:*** Health trends before and after the pandemic are examined to evaluate disruptions in service delivery (Hogan et al., 2020).
6. ***Interpretation and policy recommendations:*** Findings are synthesized to suggest targeted policy interventions aimed at improving healthcare accessibility and equity (Kieny et al., 2017).

Result and Discussion

Family Planning

Family planning is a key component of reproductive health that enables couples to decide the number and spacing of their children. In Maharashtra, family planning indicators show regional variations, influenced by socioeconomic and cultural factors. The study highlights a decline in the Medical Termination of Pregnancy (MTP) ratio in districts such as Osmanabad, Solapur, Wardha, Nagpur, Chandrapur, Buldhana, and Parbhani between 2019-20 and 2020-21 (Figure 3 & 4). These districts, particularly in the Vidarbha region, have a large population of Scheduled Castes (SC) and Scheduled Tribes (ST). The declining MTP rate suggests a shift in reproductive behaviour, possibly influenced by post-COVID conditions, with couples opting for childbirth instead of abortion. Socioeconomic factors, healthcare accessibility, and cultural beliefs play a role in this trend, emphasizing the need for targeted awareness programs on safe abortion and reproductive choices.

Sterilization remains the most common method of family planning, especially in economically weaker districts like Nandurbar, Bhandara, Gadchiroli, Gondiya, and Chandrapur (Figure 5 & 6). Female sterilization is significantly higher than male sterilization due to traditional gender norms, limited male participation, and economic constraints. However, there is a slight decline in female sterilization rates as more couples are adopting temporary contraceptive methods like oral pills, injectables, and condoms, as reported in NFHS-5.

The use of intrauterine contraceptive devices (IUCDs) has remained stable at the state level, though variations exist at the district level. While IUCD usage declined in Akola, Hingoli, Bhandara, Satara, Sangli, and Nanded, it increased in Parbhani, Aurangabad, Jalna, Solapur, and Ratnagiri (Figure 7). These disparities highlight differences in healthcare access, contraceptive awareness, and regional healthcare infrastructure. Major challenges in family planning adoption include limited education, cultural taboos, inadequate healthcare services, gender inequality, and economic barriers (Saito et al., 2016). Strengthening reproductive health education, improving contraceptive access, and implementing gender-inclusive policies can help address these challenges.

Maternal Health

Maternal health indicators, such as first-trimester registration, antenatal care (ANC), and institutional deliveries, provide crucial insights into maternal well-being in Maharashtra. The rate of first-trimester registration declined in Nashik, Amravati, Raigarh, Nandurbar, Latur, Pune, Satara, Ratnagiri, and Sindhudurg in 2020-21 (Figure 8 & 9). This suggests delays in accessing maternal healthcare services, which can affect maternal and neonatal health. However, districts like Palghar, Solapur, Osmanabad, and Akola showed improvements, indicating better outreach and healthcare access. Early registration is crucial for risk assessment, nutritional support, and early intervention in pregnancy-related complications.

Antenatal care coverage remained stable across districts, with Mumbai, Bhandara, Gondiya, Yavatmal, and Buldhana reporting an increase (Figure 10). Institutional deliveries also showed consistency, indicating sustained healthcare utilization despite pandemic-related disruptions. Some districts, including Nashik, Jalna, Kolhapur, and Nandurbar, showed an upward trend in institutional deliveries, reflecting strengthened maternal healthcare services (Figure 11).

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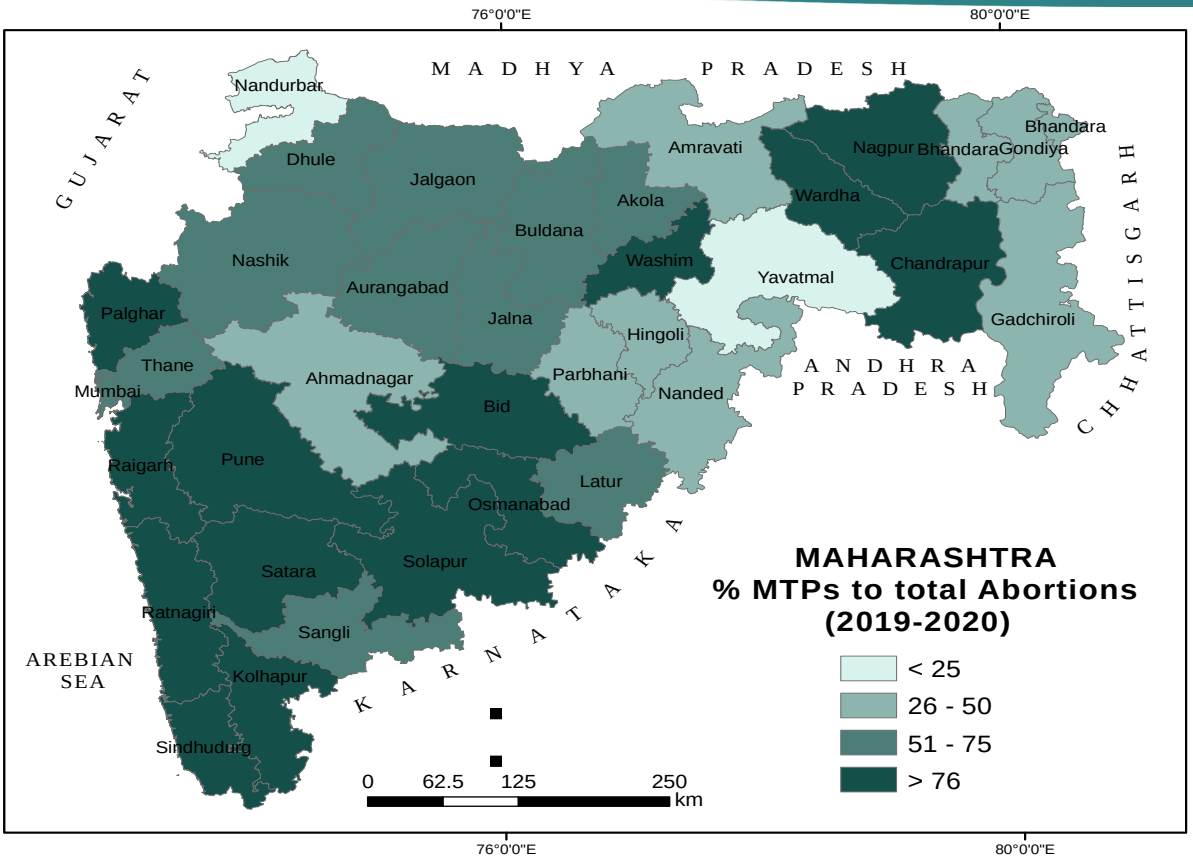

Figure 3. Proportion of MTP to total abortions (2019-20).

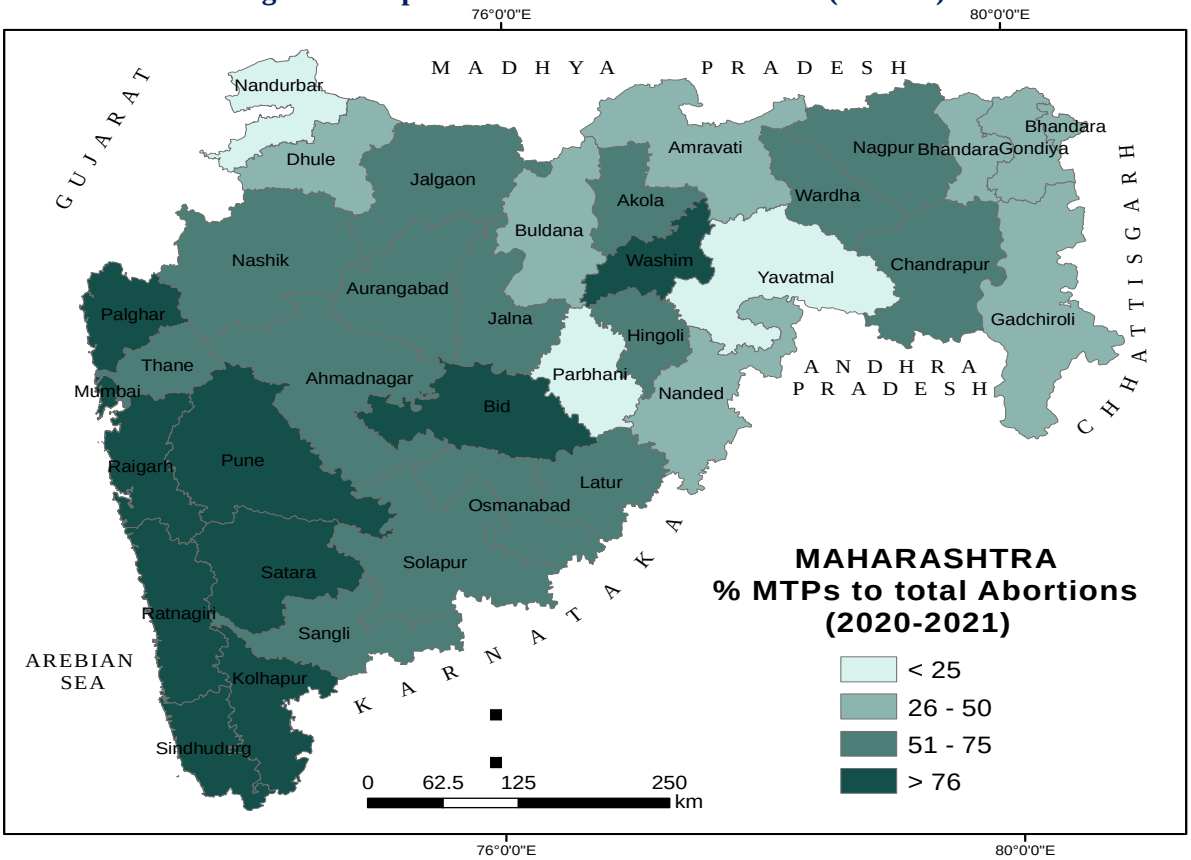

Figure 4. Proportion of MTP to total abortions (2020-21).

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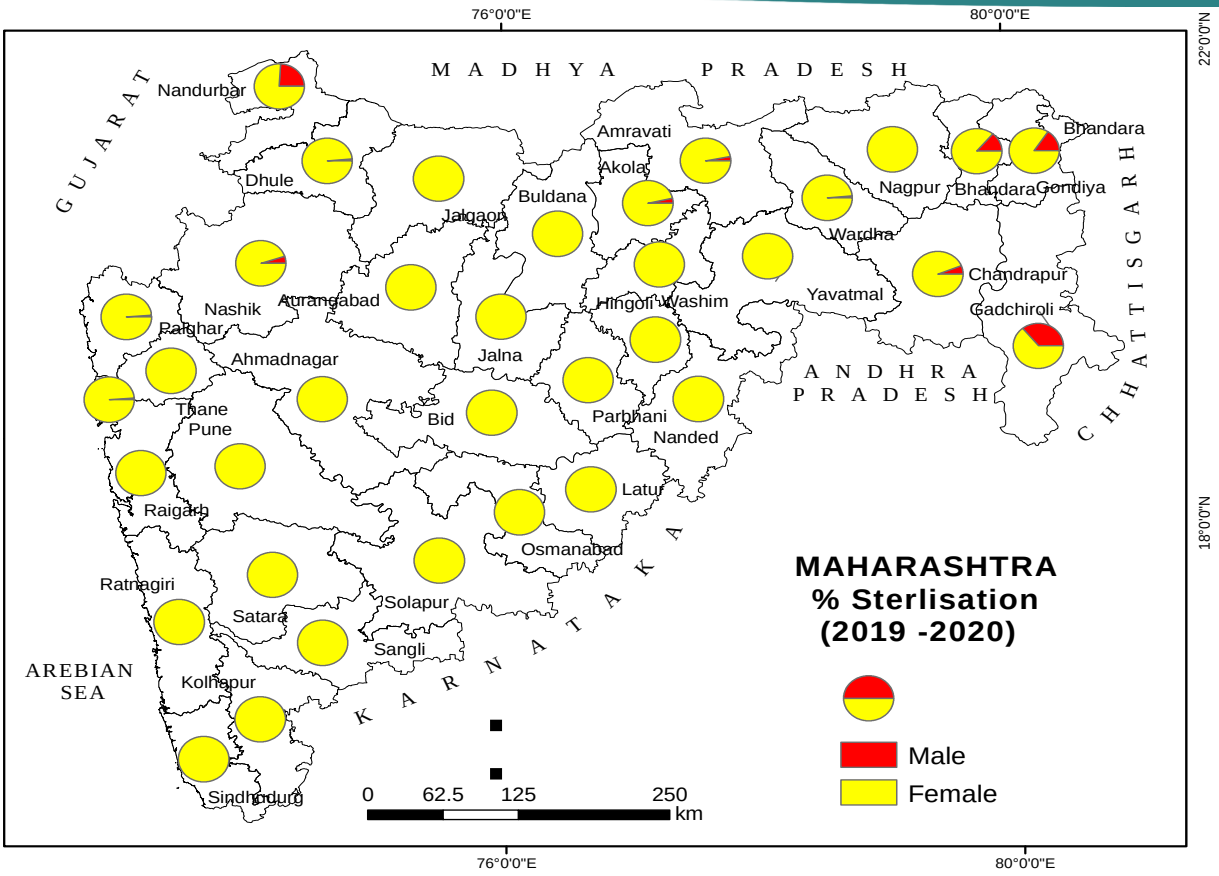

Figure 5. Sterilization rate (2019-20).

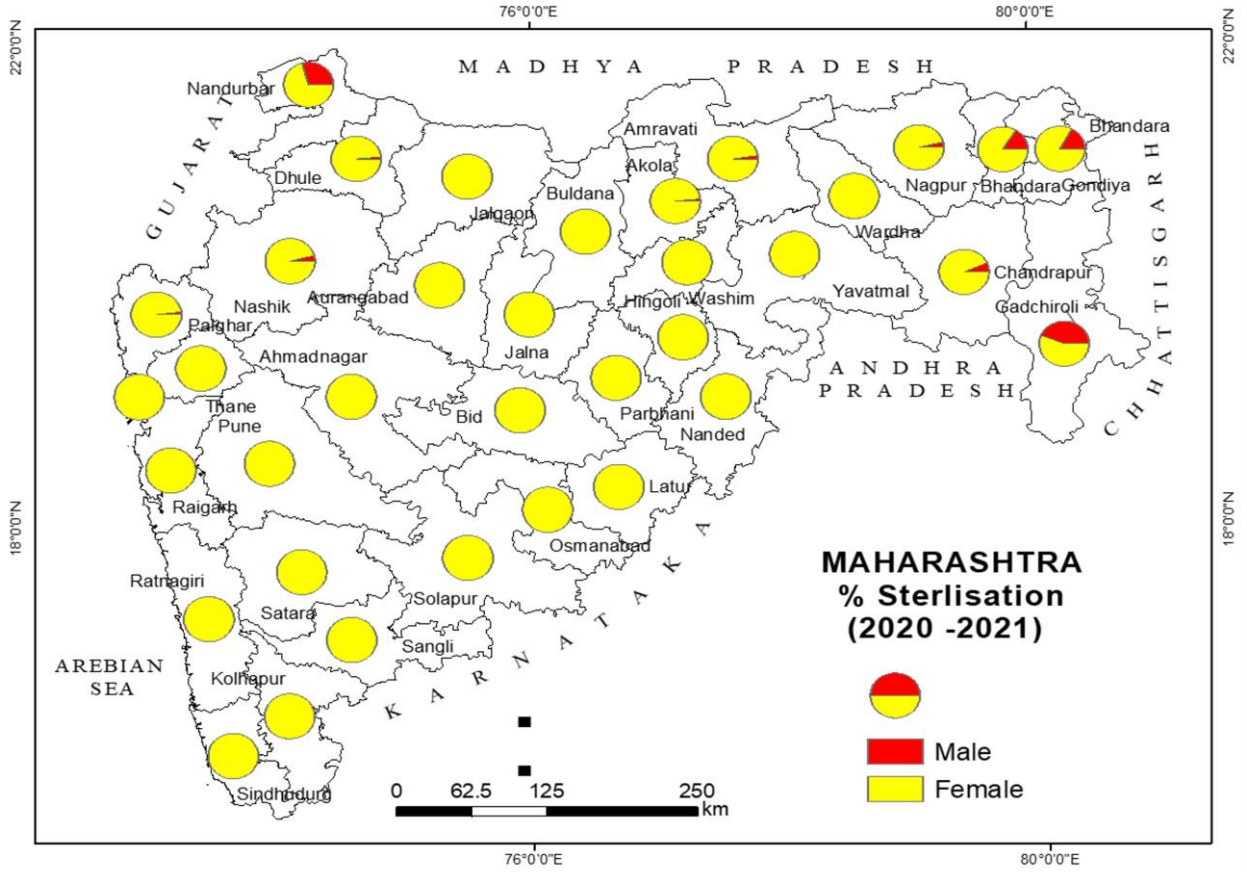

Figure 6. Sterilization rate (2020-21).

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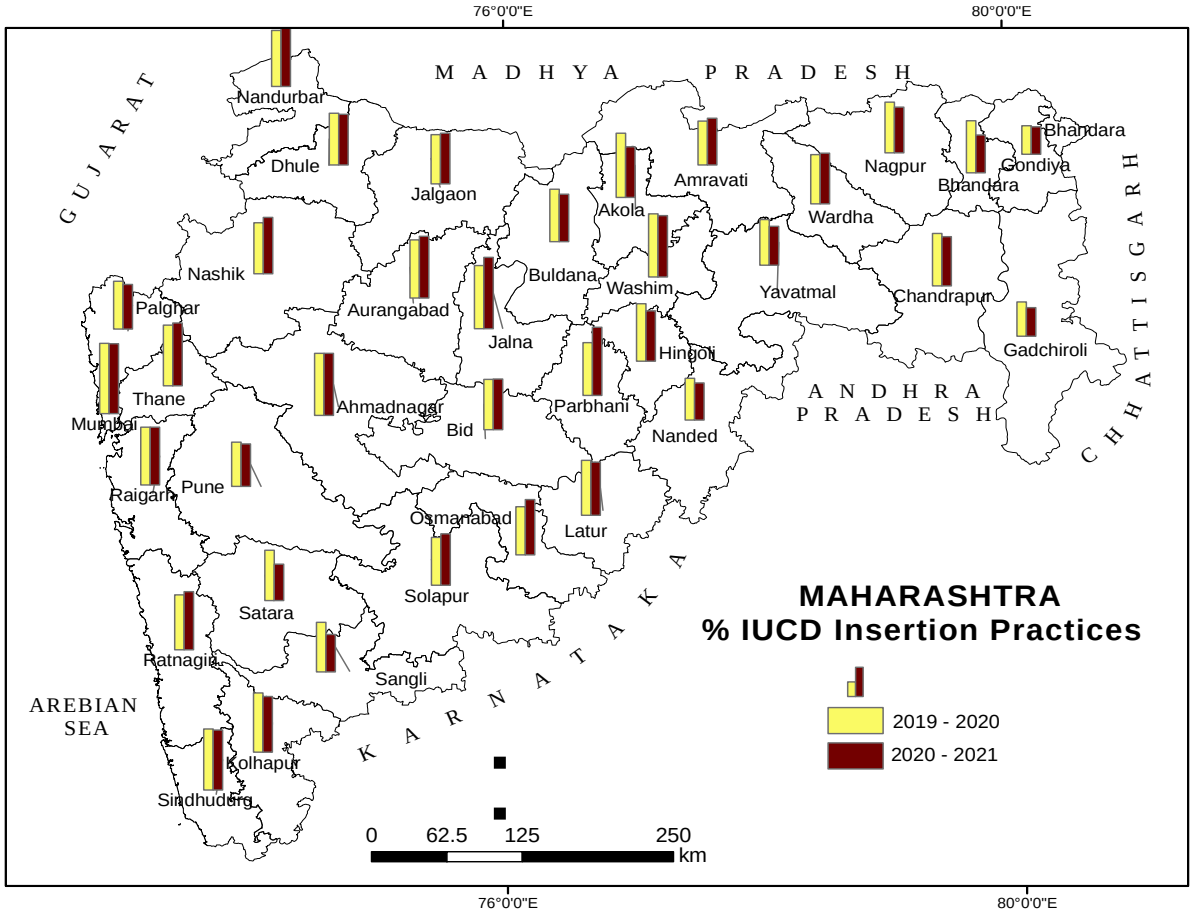

Figure 7. IUCDs insertion practices (2019-21).

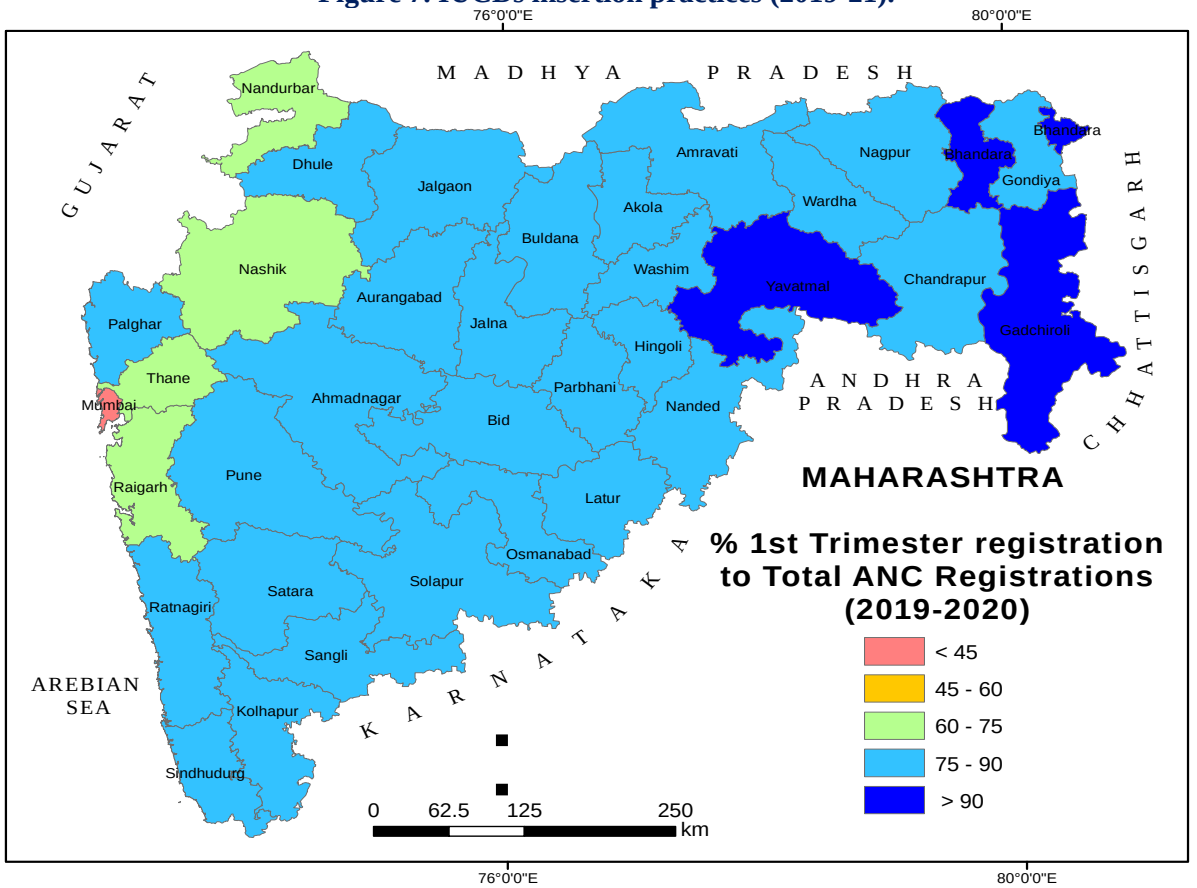

Figure 8. Rate of first-trimester registration (2019-20).

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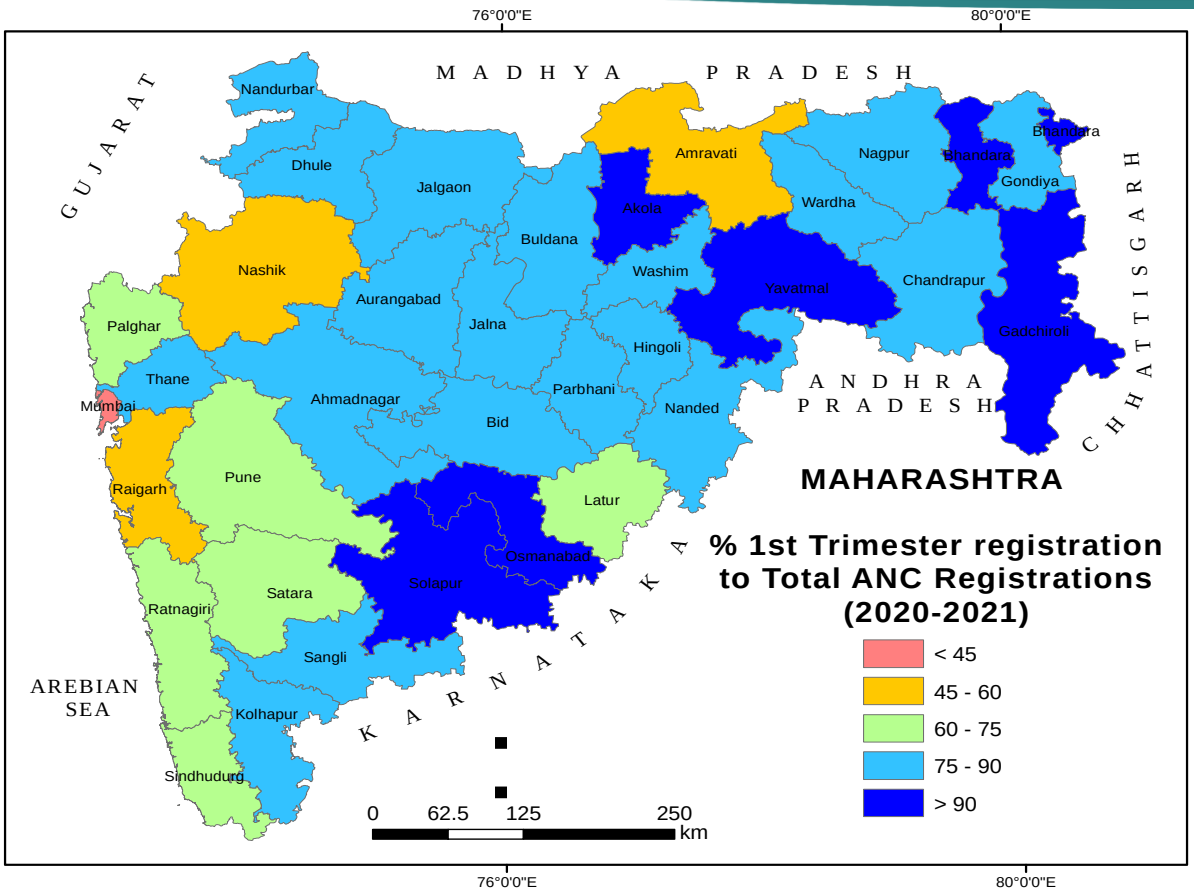

Figure 9. Rate of first-trimester registration (2020-21).

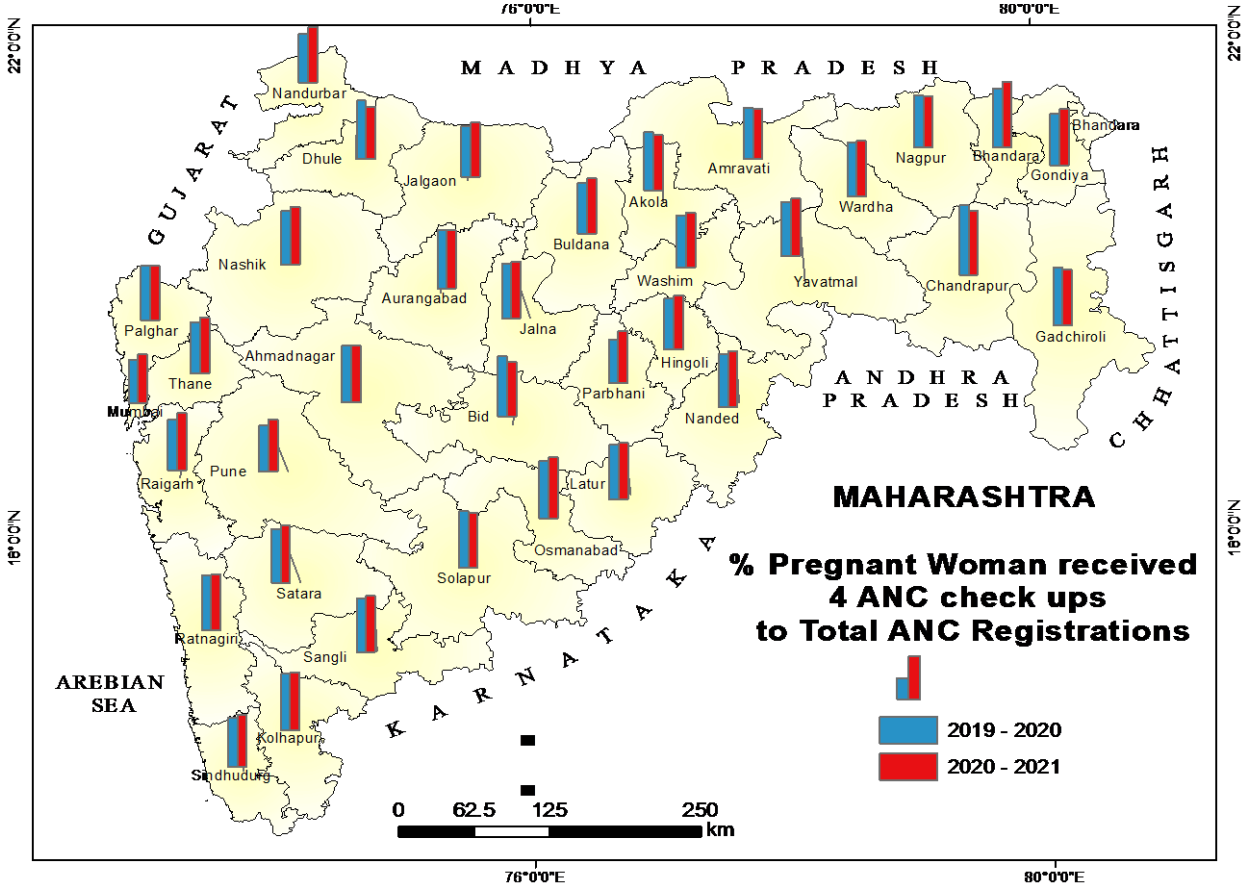

Figure 10. Pregnant women receiving 4 ANC checkups to total ANC registrations.

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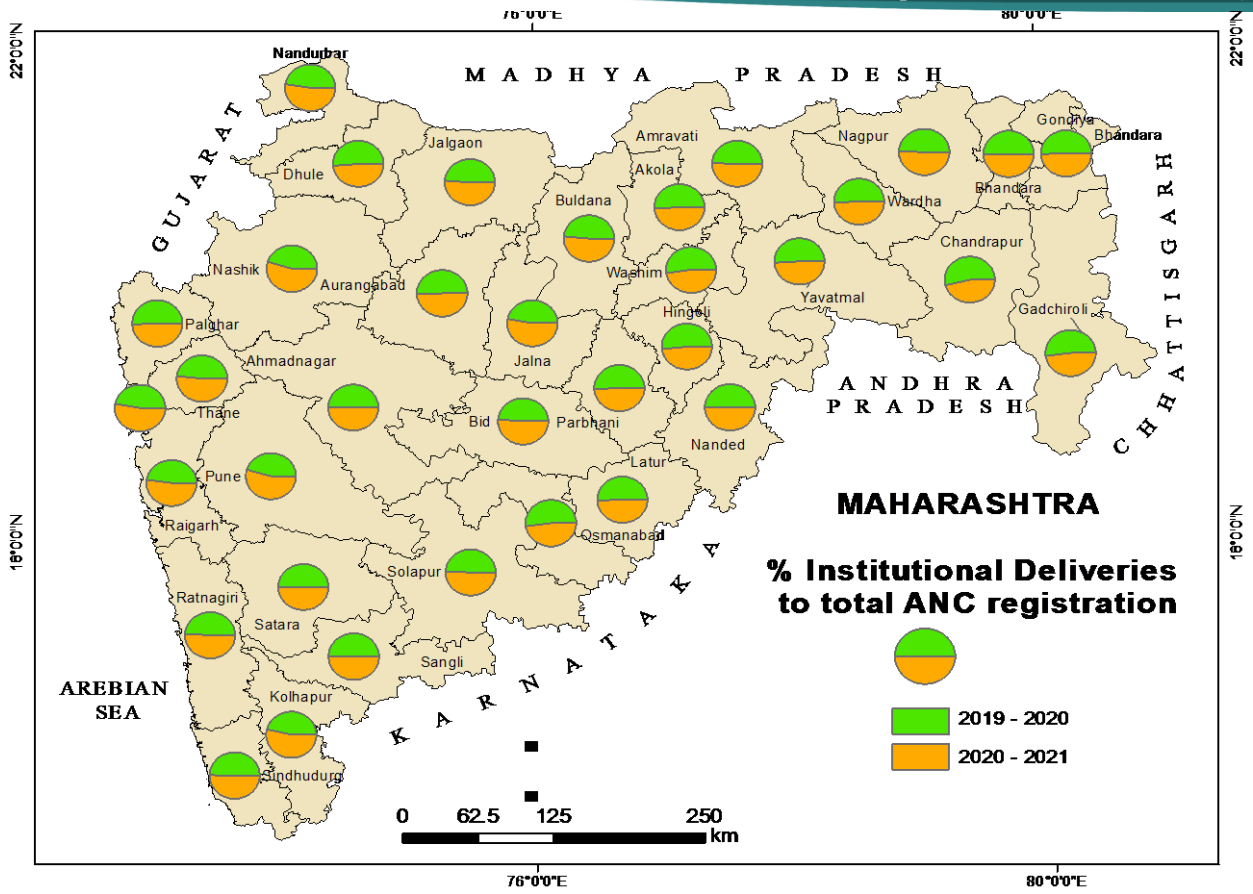

Figure 11. Institutional deliveries to total ANC registrations.

Public hospitals remain the primary choice for maternity care in economically weaker districts like Nandurbar, Gadchiroli, Bhandara, Gondiya, and Amravati. In contrast, districts with better economic conditions, such as Mumbai, Pune, Thane, and Ratnagiri, prefer private hospitals due to better facilities, specialized care, and insurance coverage. The main challenges in maternal health include inadequate healthcare access, poor prenatal care, high teenage pregnancy rates, malnutrition, and socio-economic inequalities. Addressing these issues requires better healthcare infrastructure, policy measures, and awareness campaigns to improve maternal health outcomes.

Child Health

Child health indicators, such as birth weight, immunization, and sex ratio at birth, provide a deeper understanding of neonatal and pediatric health trends in Maharashtra. The live birth to total deliveries ratio remained stable across most districts, indicating better maternal and neonatal care services post-COVID. However, districts like Beed, Solapur, Dhule, Akola, Chandrapur, and Gadchiroli recorded a decline, highlighting deficiencies in maternity services (Figure 12). Strengthening healthcare infrastructure in these areas is essential for improving birth outcomes.

Low birth weight cases (<2.5 kg) increased in Gondiya, Nashik, Nandurbar, Mumbai, Hingoli, Bhandara, and Nanded, signaling concerns about maternal nutrition and prenatal care. Conversely, districts like Dhule, Chandrapur, and Beed recorded a decline in low birth weight cases, indicating improved prenatal interventions (Figure 13). These findings highlight the need for better maternal nutrition programs and healthcare access. Immunization coverage remained consistent across Maharashtra, reflecting successful vaccination campaigns. However, continuous efforts are needed to sustain high immunization rates and address gaps in vaccination outreach.

The sex ratio at birth remains a concern, with Maharashtra reporting 929 females per 1,000 males (Census, 2011), below the national average of 940. Some districts, such as Palghar, Ahmednagar, Gondiya, Washim, and Solapur, showed improvements in the sex ratio in 2020-21 (Figure 14 & 15). However, Thane, Parbhani, Jalna, Buldhana, Wardha, Chandrapur, and Kolhapur reported declines, suggesting ongoing gender biases and selective birth practices. Addressing gender disparities requires stronger legal enforcement, awareness campaigns, and policy interventions promoting gender equality.

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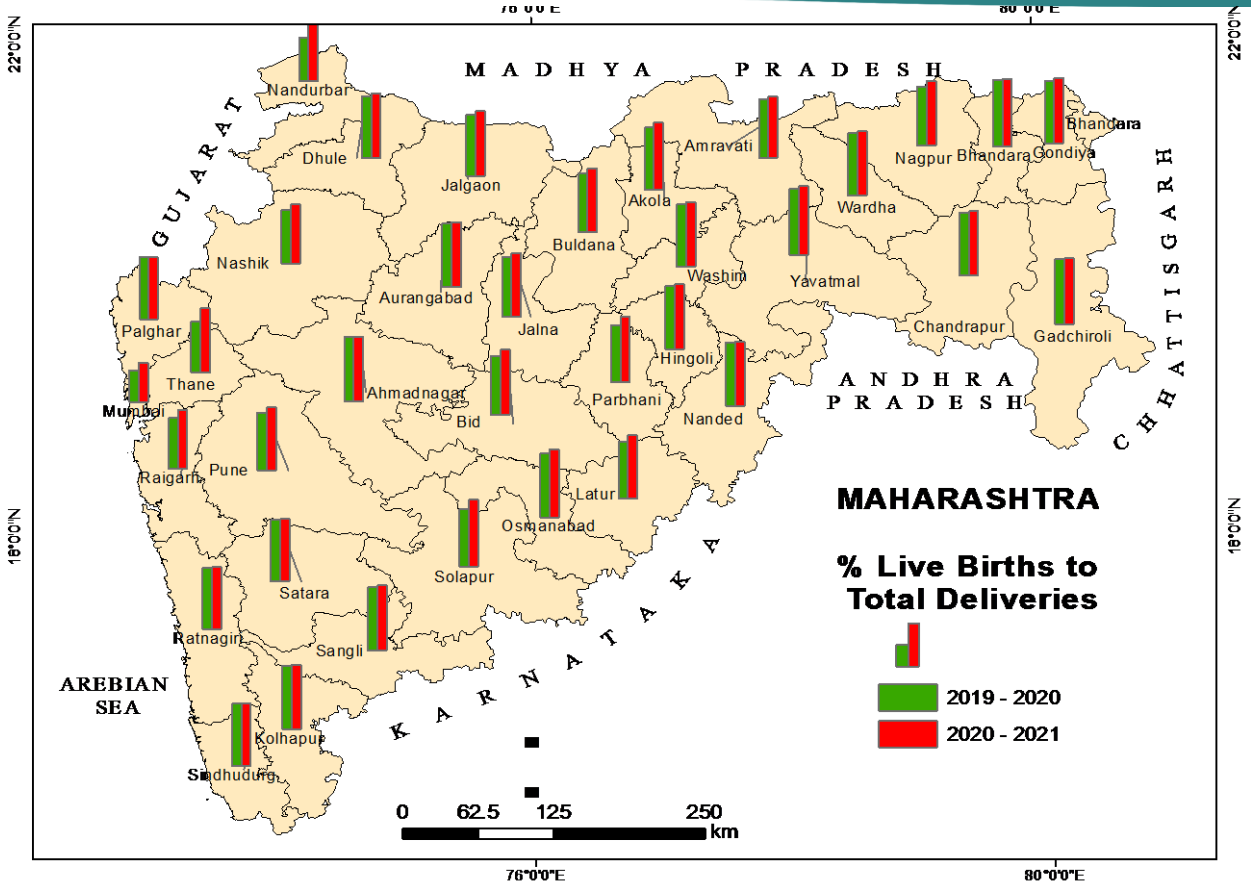

Figure 12. Live births to total deliveries.

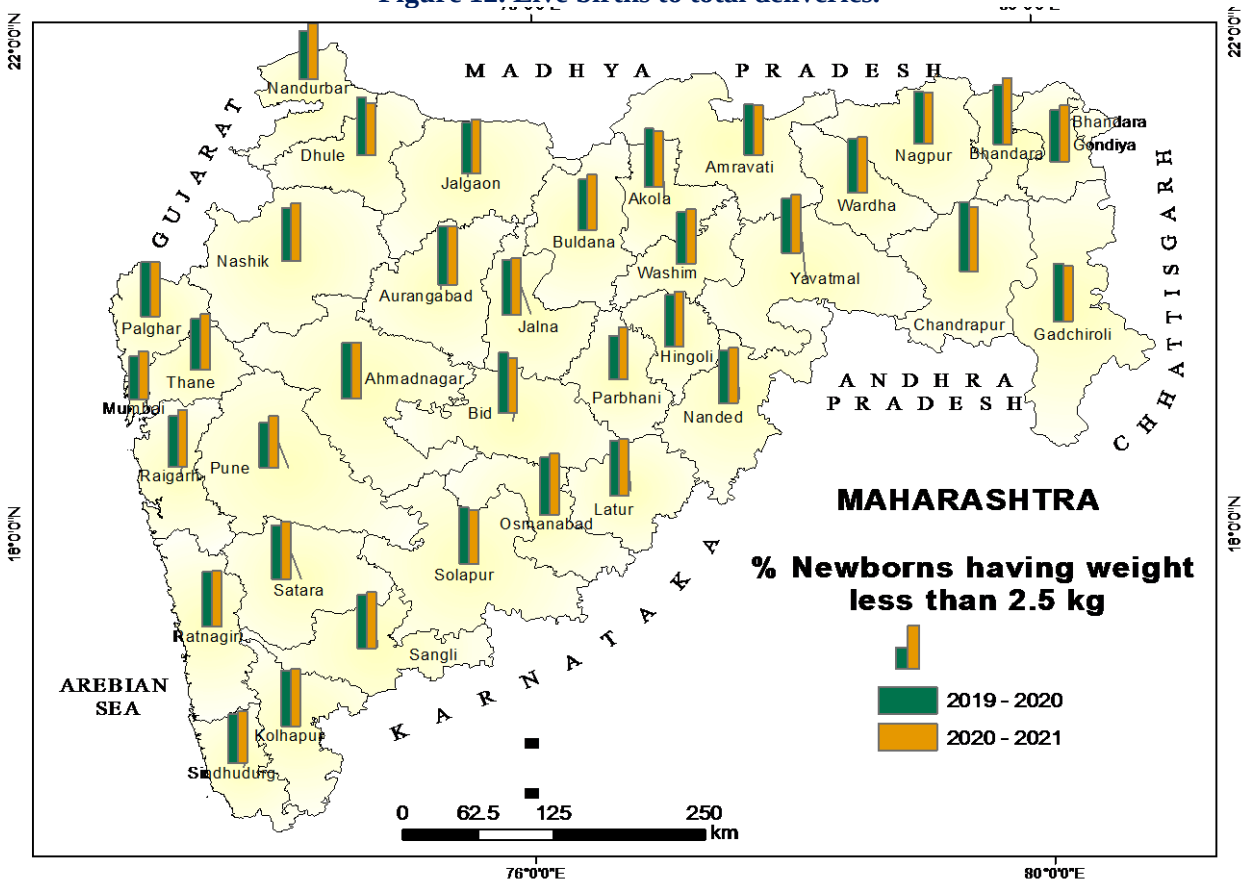

Figure 13. Newborns having weight less than 2.5kg.

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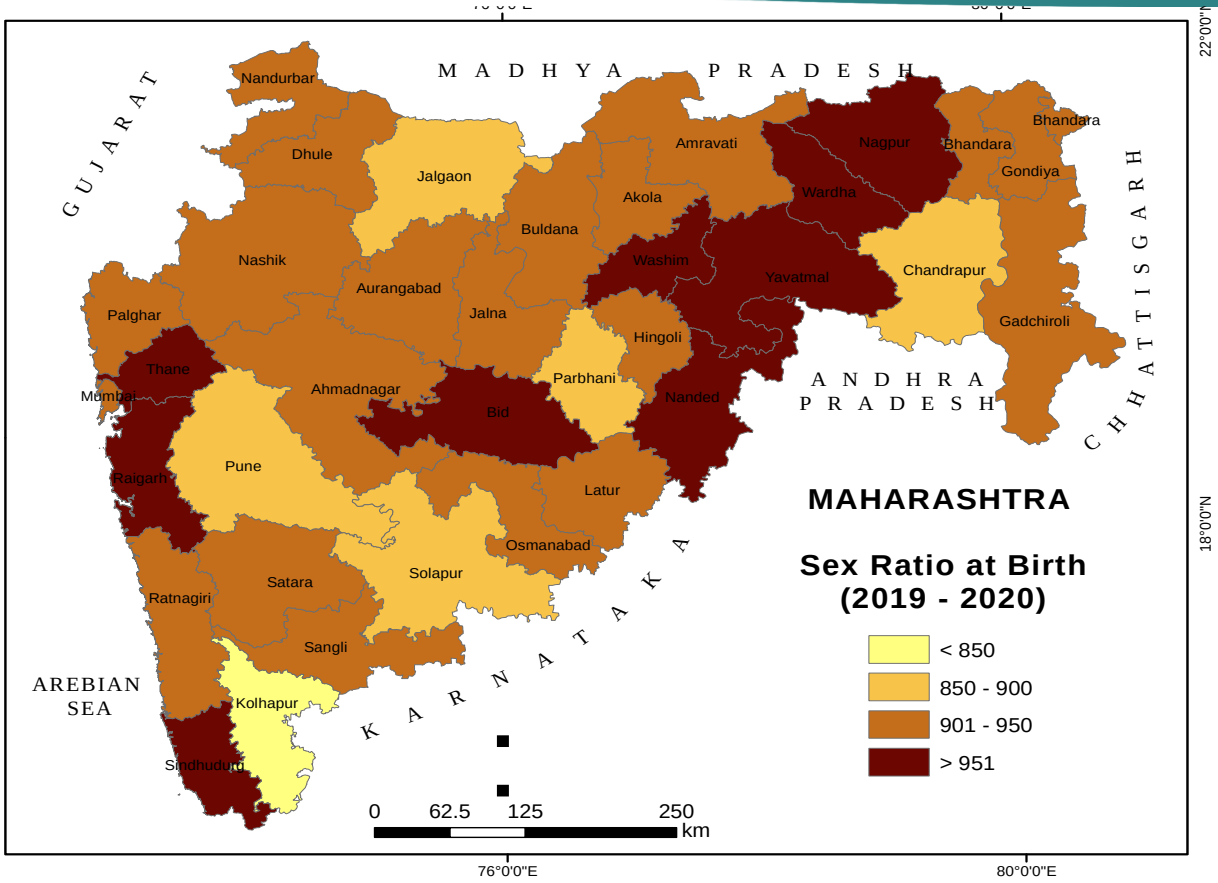

Figure 14. Sex ratio at birth (2019-20).

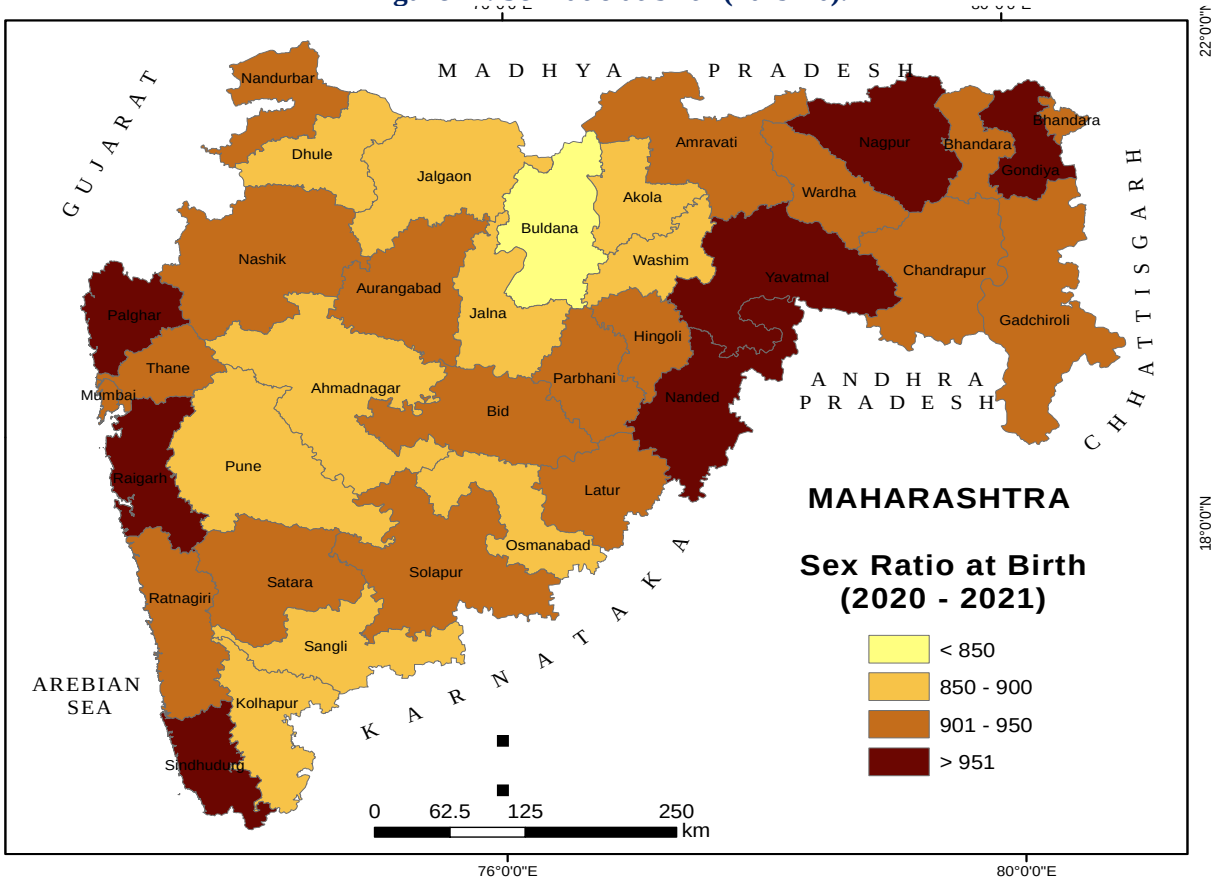

Figure 15. Sex ratio at birth (2020-21).

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Health Care Services

Healthcare services encompass a broad range of medical, diagnostic, therapeutic, preventive, and supportive services provided by professionals and institutions to promote and restore health. In Maharashtra, the Public Health Department (PHD) primarily manages primary and secondary healthcare facilities, including Primary Health Centers (PHCs), Sub-centers, First Referral Units (FRUs), and specialty hospitals for disease control. The availability of healthcare providers in public health facilities is assessed from two perspectives: managerial, which considers sanctioned and filled posts, and operational, which focuses on actual attendance and service delivery. The private healthcare sector includes practitioners from various medical systems, maternity and nursing homes, and small to large hospitals. According to Government of India norms, there should be one sub-center per 3,000–5,000 people, one PHC per 20,000–30,000 people, and one Community Health Center (CHC) per 80,000–1,20,000 people in rural and tribal areas. Maharashtra requires approximately 2,299 PHCs, but only 1,828 (79.5%) are operational, leaving a shortfall of 471 (21%) (Figure 16). The availability of private hospital beds varies across districts, with Gondia, Gadchiroli, and Yavatmal having less than 0.1 beds per 1,000 people, while Beed, Bhandara, Latur, and Sindhudurg have more than 2.0 beds per 1,000 people, indicating regional disparities in healthcare infrastructure.

The findings of this study provide a comprehensive analysis of family planning, maternal health, child health and healthcare services in Maharashtra. The result highlights that there were regional disparities and emerging trends. Family planning indicators, such as declining MTP ratios and the predominant use of sterilization in economically weaker districts, underscore socioeconomic influences and cultural norms affecting reproductive choices. The shift towards temporary contraceptive methods reflects evolving preferences post-COVID, necessitating targeted awareness programs. Maternal health indicators reveal mixed trends in first-trimester registration and institutional deliveries across districts, indicating varying healthcare access and outreach effectiveness. Challenges persist, including inadequate prenatal care and disparities in healthcare utilization between public and private facilities. Addressing these challenges requires enhanced infrastructure, policy interventions promoting gender equality and improved healthcare access, particularly in economically disadvantaged areas. Child health outcomes highlight improvements in immunization coverage but persisting concerns regarding low birth weight and sex ratio imbalances. The findings emphasize the need for sustained maternal nutrition programs and comprehensive vaccination campaigns to ensure optimal child health outcomes statewide.

Healthcare service availability in Maharashtra remains uneven, particularly in rural and tribal areas. The shortfall in operational Primary Health Centers (PHCs) and disparities in hospital bed availability highlight gaps in healthcare infrastructure. Strengthening public healthcare facilities, ensuring adequate staffing and enhancing service delivery mechanisms are critical to improving overall health outcomes. Addressing these challenges through targeted policy measures, community-based interventions and improved healthcare accessibility will contribute to sustainable improvements in family

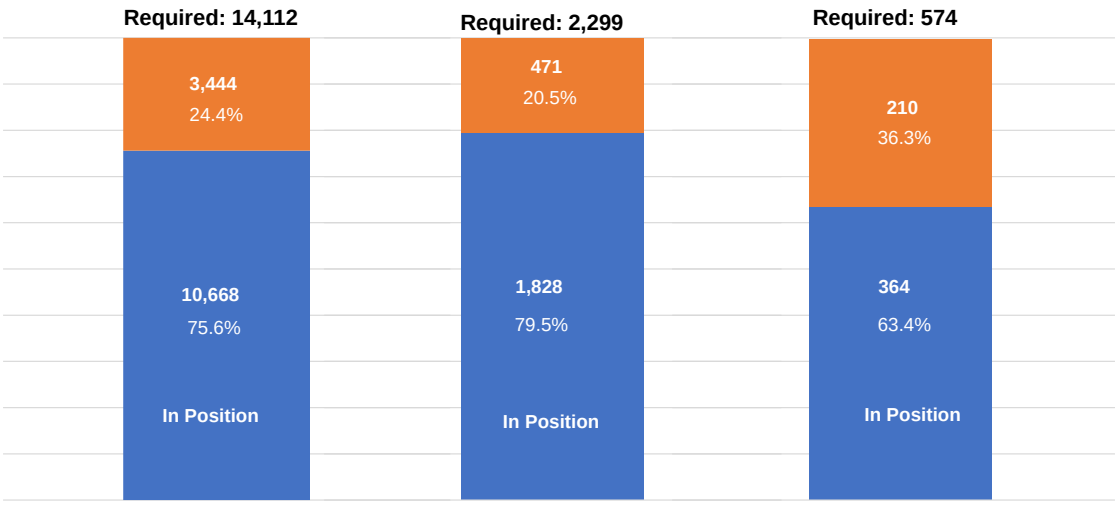

Figure 16. Public Health Infrastructure in Maharashtra (2021) [Note: PHCs = Primary Health Centers, CHCs = Community Health Centers; Source: Government of India, Ministry of Health and Family Welfare, 2019].

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planning, maternal health and child health across the state.

Conclusion

The assessment of healthcare services in Maharashtra provides insights into child health, maternal health, and family planning. The results highlight disparities in healthcare access, availability of medical professionals, and infrastructure gaps, mainly in rural and underserved areas. The analysis of family planning, maternal health, and child health indicators across Maharashtra highlights regional disparities, emerging trends, and persistent challenges. Although there has been progress in areas such as institutional deliveries, immunization, and live birth outcomes, issues like low contraceptive usage, maternal mortality risks, and child malnutrition remain. Addressing these challenges requires comprehensive policy interventions, stronger healthcare infrastructure, enhanced awareness programs, and gender-inclusive reproductive health strategies.

Additionally, maternal health can be enhanced through better antenatal and postnatal care, skilled birth attendance, and emergency obstetric services, ensuring safer childbirth outcomes. Strengthening immunization programs, improving child nutrition, and expanding access to quality healthcare services are essential to improving child health indicators. Geospatial data analysis plays a key role in identifying high-priority areas, enabling policymakers to allocate resources efficiently and implement data-driven interventions. The research provides a foundation for targeted interventions, resource allocation, hotspot identification, policy formulation, and continuous monitoring. By implementing these recommendations will help the state move towards a comprehensive and inclusive healthcare system, ensuring improved maternal and child health while promoting sustainable family planning practices across Maharashtra.

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Conflict of Interest

The authors have no conflict of interest to declare for this study.

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